DOCKETED	
Docket Number:	25-EPIC-01
Project Title:	Electric Program Investment Charge 2026–2030 Investment Plan (EPIC 5)
TN #:	265471
Document Title:	Derya Dursun Balci Comments - 25-EPIC-01 Research Idea - AI as a tool for energy efficiency
Description:	N/A
Filer:	System
Organization:	Derya Dursun Balci
Submitter Role:	Applicant
Submission Date:	8/8/2025 2:59:20 PM
Docketed Date:	8/8/2025

Comment Received From: Derya Dursun Balci
Submitted On: 8/8/2025
Docket Number: 25-EPIC-01

25-EPIC-01 Research Idea - AI as a tool for energy efficiency

Please see attached file

Additional submitted attachment is included below.

Electric Program Investment Charge 2026–2030 (EPIC 5) Research Concept Proposal Form

The California Energy Commission (CEC) is currently soliciting research concept ideas and other input for the Electric Program Investment Charge 2026–2030 (EPIC 5) Investment Plan. For those who would like to submit an idea for consideration, please complete this form and submit it to the CEC by **August 8, 2025**. More information about EPIC 5 is available below.

To submit the form, please visit the e-commenting link: https://efiling.energy.ca.gov/EComment/ECommentSelectProceeding.aspx and select the Docket **25-EPIC-01**. Enter your contact information and then use the "choose file" button at the bottom of the page to upload and submit the completed form. Thank you in advance for your input.

1. ***Please provide the name, email, and phone number of the best person to contact should the CEC have additional questions regarding the research concept:***

Name: Derya Dursun Balci, PhD, PE
Email: derya@cwatertech.com
Phone: 407-7658693

2. ***Please provide the name of the contact person's organization or affiliation:***

Organization: Caliskaner Water Technologies Inc.
Address: 2733 Brookshire Cir., Woodland, CA, 95776

3. ***Please provide a brief description of the proposed concept that you would like the CEC to consider as part of the EPIC 5 Investment Plan. What is the purpose of the concept, and what would it seek to do? Why are EPIC funds needed to support the concept?***

The integration of artificial intelligence (AI) and machine learning (ML) technologies in wastewater treatment plants (WWTPs) represents a paradigm shift toward intelligent, energy-efficient, and optimized operations. These technologies address critical challenges including energy consumption optimization, operational efficiency enhancement, and the development of smart decision-making capabilities that reduce human intervention while maintaining wastewater treatment quality standards.

Our concept proposes an **AI/ML-based digital framework to enable energy self-sufficient wastewater treatment systems** by first minimizing energy consumption through intelligent control of operations that require high energy demand (aeration, pumping systems, and sludge processing) while also addressing systemic inefficiencies, including leaks, over-aeration, and unnecessary recirculation. Subsequently, the system maximizes on-site energy generation through enhanced anaerobic digestion and co-generation strategies (e.g., through combined heat and power systems). The goal is to transform conventional wastewater treatment plants into intelligent facilities with increased levels of autonomy through the integration of machine learning, artificial intelligence, and digital twin technologies.

This involves the deployment of AI/ML algorithms such as reinforcement learning, adaptive regression, and anomaly detection for real-time process control, predictive maintenance, and energy optimization. A digital twin of the treatment system can be developed using dynamic process simulators and synchronized with real-time data via cloud or edge platforms. This enables scenario analysis, forecasting, and simulation of operational strategies. SCADA systems act as the interface for sensor data acquisition and actuation, ensuring seamless communication between the physical plant and the digital layer. Together, these components create a closed-loop decision-making environment that enables data-informed, autonomous control while maintaining treatment reliability and regulatory compliance.

The following examples illustrate how the concept is implemented in practice:

i. Advanced sensor networks (e.g., turbidity, DO, flow, biogas yield) and external data sources will feed into a secure cloud-integrated platform to enable predictive and real-time decision-making. The system also incorporates adaptive calibration of chemical dosing in secondary treatment units, which currently rely on fixed setpoints and operator instructions. By leveraging real-time sensor inputs, the platform will dynamically adjust the chemical compound dosages (e.g., coagulants, pH adjusters) to optimize treatment performance, reduce chemical overuse, and respond to variations in influent characteristics.

ii. Additionally, it enables dynamic aeration control based on real-time flow and DO measurements. Variations in influent flow patterns require responsive adjustment of aeration rates to ensure energy-efficient operation, maintain process stability, and support proactive management of load variability.

EPIC funds are essential to develop and demonstrate this intelligent operational framework, enabling timely and optimal decision-making across wastewater operations, reducing energy demand while increasing resilience and resource recovery. The concept directly contributes to California's transition toward self-sufficient utilities..

4. ***In accordance with Senate Bill 96[i], please describe how the proposed concept will "lead to technological advancement and breakthroughs to overcome barriers that prevent the achievement of the state's statutory energy goals." For example, what technical and/or market barriers or customer pain points would the proposed concept address that would lead to increased adoption of clean energy technology or innovation? Where possible, please provide specific cost and performance targets that need to be met for increased industry and consumer acceptance. For scientific analysis and tools, provide more information on what data and information gaps the proposed concept would help fill, and which specific parties or end users would benefit from the results, and for what purpose(s)?***

In accordance with Senate Bill 96, how the proposed concept will lead to technological advancement and breakthroughs to overcome barriers that prevent the achievement of the state's statutory energy goals.

The proposed solution addresses major barriers that prevent wastewater utilities from achieving Net-Zero and operational autonomy, including static control strategies, siloed data usage, and energy-intensive processes.

Key Barriers Addressed:

- Manual operation with minimal real-time data integration
- Fixed model parameters (Fixed correlation factors, stoichiometric relationships)
- Gaps between process control decision of different processes at WWTPs which lead to excessive energy usage (i.e., unnecessary aeration and pumping)

- Delay in detecting heavy or toxic load to utilities
- Underused real-time sensor data (e.g., DO, turbidity, flow)

Breakthrough Approach:

- AI and digital twins for alarms, predictive control and scenario testing
- Projected 20–30% reduction in aeration and pumping energy demand [3, 4, 5]
- Optimization of anaerobic digestion conditions for higher biogas yield and energy production
- Seamless SCADA integration for near real-time operation control

Data Gaps Addressed:

- Use of operational data for training ML models
- Forecasting of sludge generation
- Development of alarms for toxicity to maintain stable and proactive operation in activated sludge basin
- Integration of weather (wet – weather events) and external load profiles for proactive operation

Target Beneficiaries:

- Municipal utilities, state regulators, technology providers, underserved communities

5. ***Please describe the anticipated outcomes if this research concept is successful, either fully or partially. For example, to what extent would the research reduce technology or ratepayer costs and/or increase performance to improve the overall value proposition of the technology? What is the potential of the innovation at scale? How will the innovation lead to ratepayer benefits in alignment with EPIC's guiding principles to improve safety,[ii] reliability,[iii] affordability,[iv] environmental sustainability,[v] and equity?[vi]***

Expected Results:

- Up to 30% reduction in aeration and pumping energy use through optimization [1, 2, .. , 5]
- 15% increase in biogas production through digestion optimization [6]
- 15% lower GHG emissions via energy self-sufficiency [4]
- Optimized chemical use (polymer, ferric chloride) via sensor based controls
- Reduced operator burden and increased decision accuracy

EPIC Principle Benefits:

- Affordability: Energy savings and reduced OPEX (i.e., labor hours, maintenance requirement) at WWTPs
- Sustainability: Enhanced circularity and resource recovery

- Reliability: Autonomous and stable operation under dynamic conditions such as wet weather events or shock toxic loading conditions
- Equity: Scalable solution for small-to-mid-size municipalities
- Safety: Traceable, transparent, and rule-based decision support

6. ***Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed research concept.***

Quantitative:

- kWh/MGD reduction in energy intensity
- % decrease in chemical consumption
- % improvement in TSS estimation accuracy
- % increase in Biogas yield
- Energy recovery

Qualitative:

- Meeting regulatory compliance
- Reduction in operator dependance
- System responsiveness to dynamic loading
- Regional deployment potential
- Data traceability and robustness

7. ***Please provide references to any information provided in the form that supports the research concept's merits. This can include references to cost targets, technical potential, market barriers, equity benefits, etc.***

In a comprehensive global review is conducted on the application of machine learning algorithms for optimizing energy usage in wastewater treatment systems, focusing on five key domains: energy consumption (EC), aeration energy (AE), pumping energy (PE), sludge treatment energy (STE), and greenhouse gas emissions (GHG) [1]. The review categorizes studies based on scale, geographic location, implementation year, performance metrics, and software platforms. Among the techniques evaluated, Artificial Neural Networks (ANNs) emerged as the most frequently applied algorithm, followed closely by Fuzzy Logic (FL) and Random Forest (RF) models for predictive control and operational optimization. In addition, Genetic Algorithms (GA) and Particle Swarm Optimization (PSO) were identified as the dominant metaheuristic approaches for fine-tuning control parameters and optimizing energy-intensive processes. Reported outcomes across the reviewed studies show that these algorithms have achieved energy reductions ranging from modest improvements (<10%) to substantial savings exceeding 20%, depending on the process targeted and the quality of available operational data. These findings underscore the suitability of AI and ML for scalable deployment in wastewater treatment applications aimed at energy efficiency and emissions reduction.

A methodology for enabling real-time control of NH_4-N removal in wastewater treatment systems is given by other researchers [2]. The methodology was developed using a case-study SBR system treating residential wastewater. A variety of machine learning techniques (Linear regression, neural networks, Bayesian regularization, etc.) were used and compared to develop suitable soft sensors that could enable RTC of wastewater treatment systems. It is shown that Bayesian regularization and would achieve an average treatment time saving of 67%, resulting in an average energy saving of 51% of electricity costs.

Approximately 30 studies reported significant energy savings ranging from 10% to over 40%, primarily through optimized aeration control, pump operation, and process parameter tuning [3, 4, 5].

On the other hand, other research indicated that [6], anaerobic digestion (AD) process performance can be significantly improved through intelligent automation, computational intelligence (CI), and machine learning (ML) methods. Several researchers demonstrate that by applying supervised learning algorithms (e.g., support vector machines, artificial neural networks) in combination with spectroscopic sensors (UV/Vis and MIR), operators can closely monitor key process variables such as volatile fatty acids and ammonium. This enables more accurate process control and enhances the stability of biogas production. Additionally, simulation-based optimization using Particle Swarm Optimization (PSO) and Genetic Algorithms (GA), grounded in the ADM1 model, allows for optimal feed strategies to be developed. These improvements in substrate management and monitoring collectively lead to more efficient and stable biogas generation, suggesting strong potential for enhancing on-site energy recovery in wastewater treatment plants through digital and data-driven methods.

References

[1] Abunama, T., Dellieu, A., & Nonet, S. (2024). Advancements in machine learning modelling for energy and emissions optimization in wastewater treatment plants: A systematic review. *Water and Environment Journal*, *38*(4), 554-572.

[2] Fox, S., McDermott, J., Doherty, E., Cooney, R., & Clifford, E. (2022). Application of neural networks and regression modelling to enable environmental regulatory compliance and energy optimisation in a sequencing batch reactor. *Sustainability*, *14*(7), 4098.

[3] Mao, Z., Li, X., Zhang, X., Li, D., Lu, J., Li, J., & Zheng, F. (2024). Optimization of effluent quality and energy consumption of aeration process in wastewater treatment plants using artificial intelligence.Journal of Water Process Engineering. https://doi.org/10.1016/j.jwpe.2024.105384

[4] Lu, H., Meng, Z., Bao, Z., Song, S., Shou-yi, Z., Li, Y., Wu, Q., Wang, H., & Guo, W.-Q. (2024). Deep Learning-Based Multiobjective Optimization for Balancing Effluent Quality, Operational Cost, and Greenhouse Gas Emissions in Wastewater Treatment Plant Control.ACS ES&T Water. https://doi.org/10.1021/acsestwater.4c00073

8. ***The EPIC 5 Investment Plan must support at least one of five Strategic Goals:[vii]***
    a. ***Transportation Electrification***
    b. ***Distributed Energy Resource Integration***
    c. ***Building Decarbonization***
    d. ***Achieving 100 Percent Net-Zero Carbon Emissions and the Coordinated Role of Gas***
    e. ***Climate Adaptation***

    Please describe in as much detail as possible how your proposed concept would support these goals.

d. Achieving 100 Percent Net-Zero Carbon Emissions and the Coordinated Role of Gas

The concept directly supports California's Net-Zero goal by reducing energy demand through AI-optimized aeration and pumping, while increasing renewable energy generation via enhanced anaerobic digestion. The biogas produced is utilized mainly to offset the energy requirements of the facilities and also converted to electricity by using combined heat and power systems (CHP), displacing fossil fuels. These innovations, when scaled, enable wastewater utilities to become net producers of clean energy, actively participating in the coordinated role of gas in the decarbonized energy future.

e. Climate Adaptation

The system also improves resilience by enabling autonomous and adaptive responses to climate-driven events such as storm surges, temperature variation, and prolonged droughts. By enabling decentralized, data-informed control, the solution increases the reliability and safety of wastewater services under unpredictable conditions. This dual benefit of mitigation and adaptation places the concept at the intersection of California's most pressing energy-water challenge.

About EPIC

The CEC is one of four EPIC administrators, funding research, development, and demonstrations of clean energy technologies and approaches that will benefit electricity ratepayers of California's three largest investor-owned electric utilities.

EPIC is funded by California utility customers under the auspices of the California Public Utilities Commission.

To learn more about EPIC, visit: https://www.energy.ca.gov/programs-and-topics/programs/electric-program-investment-charge-epic-program

EPIC 5 documents and event notices will be posted to: https://www.energy.ca.gov/proceeding/electric-program-investment-charge-2026-2030-investment-plan-epic-5

Subscribe to the EPIC mailing list to stay informed about future opportunities to inform the development of EPIC 5: https://public.govdelivery.com/accounts/CNRA/signup/31897

---

i See section (a) (1) of Public Resources Code 25711.5 at: https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=PRC&sectionNum=25711.5.

ii EPIC innovations should improve the safety of operation of California's electric system in the face of climate change, wildfire, and emerging challenges.

iii EPIC innovations should increase the reliability of California's electric system while continuing to decarbonize California's electric power supply.

iv EPIC innovations should fund electric sector technologies and approaches that lower California electric rates and ratepayer costs and help enable the equitable adoption of clean energy technologies.

v EPIC innovations should continue to reduce greenhouse house gas emissions, criteria pollutant emissions, and the overall environmental impacts of California's electric system, including land and water use.

vi EPIC innovations should increasingly support, benefit, and engage disadvantaged vulnerable California communities (DVC). (D.20-08-046, Ordering Paragraph 1.) DVCs consist of communities in the 25 percent highest scoring census tracts according to the most recent version of the California Communities Environmental Health Screening Tool (CalEnviroScreen), as well as all California tribal lands, census tracts with median household incomes less than 60 percent of state median income, and census tracts that score in the highest 5 percent of Pollution Burden within CalEnviroScreen, but do not receive an overall CalEnviroScreen score due to unreliable public health and socioeconomic data.

vii In 2024 the CPUC adopted five Strategic Goals to guide development of the EPIC 5 Investment Plan. A description of the goals can be seen in Appendix A of CPUC Decision 24-03-007 available at: https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M527/K228/527228647.PDF